REMARKS

Claims 1, 5, and 7 are currently pending in this application, as amended. Claims 1, 5 and 7 have been amended to more particularly point out and distinctly claim the subject matter the Applicants regard as the invention and to put them in better U.S. form. Claims 2-4 and 6 have been canceled. The Specification has been amended to use proper idiomatic English and to clarify several portions of the disclosure as requested the Examiner. No new matter has been added by the Amendment to the Specification. No new matter has been added by the Amendment.

Objections to the Specification

The Specification has been objected to under 37 C.F.R. § 1.71 as not being understandable in several parts. The Examiner points to several specific locations in the Specification which are not understandable. Further, the Examiner has indicated that a Substitute Specification in proper idiomatic English and in compliance with 37 C.F.R. § 1.52(a) and (b) is required.

The Applicants have amended the Specification to include proper idiomatic English throughout and specifically to address the portions of the Specification pointed to by the Examiner as not being understandable. No new matter has been added to the Specification by the Amendments. Accordingly, the Applicants respectfully request that the objection to the Specification under 37 C.F.R. § 1.71 be withdrawn.

Objections to the Drawings

The Examiner has objected to the drawings under 37 C.F.R. § 1. 83(a) because the drawings must show every feature of the invention specified in the claims. The Examiner states that the test generating computer (TGC) for generating a test input in a test signal position bit, the trip algorithm computer (TAC) for receiving plant operating parameters via a plurality of measuring channels, the voting algorithm computer (VAC) for receiving trip signals from each of the plant operating parameters determined by said TAC, the pattern recognition computer

(PRC) for expecting a signal pattern from the state of the reactor must be shown or the features canceled from the claims.

The present invention is directed to a method for testing operating of components of a reactor protection system including a TGC, TAC, VAC and PRC. These components are in a normal or conventional nuclear protection system that uses four independent channels to check operating parameters used in a nuclear power plant. Fig. 1 shows a schematic view of a digital online active test-plant protection system (DOAT-PPS) in accordance with the present invention showing one of the four channels. Fig. 2 compares a conventional dynamic safety system (DSS) having four channels to the DOAT-PPS of the present invention having four channels, and therefore, Fig. 2 shows that there are four channels and Fig. 1 shows details of one of the four like channels. The test generating computer (TGC) is numbered 110 in Fig. 1. The test algorithm computer (TAC) is numbered 120 in Fig. 1. The voting algorithm computer (VAC) is numbered 130 in Fig. 1. The pattern recognition computer (PRC) is numbered 140 in Fig. 1. The TGC 110 generates the test input based on software programming and communicates the signal to the TGC 110. The TGC 110 receives safety parameters as an input signal from an environment neutron flux monitoring system (ENFMS), a remote shutdown panel and core protection calculator system (CPCS) via an analog input module (AI) or a digital input module (DI). Those signals are indicated as "field" and "signal," respectively, at the TGC 110.

Applicants have provided a new drawing sheet, Fig. 3, which depicts a conventional, prior art, four channel DSS as outlined in the third column of Fig. 2, in order to help clarify the conventional DSS in view of the Specification and original drawings. Such DSS systems are well known in the art. Therefore, adding Fig. 3 would not constitute new matter because the characteristics of the prior art DSS are set forth in Fig. 2 in conjunction with the elements described in the Specification that are not inventive in themselves (i.e., the TAC, VAC and four channels).

An explanation of the function of the system with use of the drawings may be helpful in showing that the drawings support the claims, as amended. The TGC 110 generates a test input for self diagnosis, the test input being inserted between actual safety parameters as a

test parameter and a test signal position bit indicating a position information of the test input in memory of the TGC. For example, it is assumed that there are five (5) safety parameters and a second safety parameter has to have a value which should not be beyond "50." The TGC sets the value to "60" and generates a test input including the modified second safety parameter.

The TAC 120 receives the safety parameters through the TGC 110 from a plurality of measuring channels which are physically and electrically isolated from each other and then compares the safety parameter and predetermined limit values by the safety parameters, if there is a test input by the TGC 110. The TAC 120 contains a trip algorithm and the TAC 120 determines the state of each of the safety parameters by comparing the safety parameters received from the TGC 110 with a predetermined limit value using the trip algorithm. In the example, the TAC 120 can find that the value of the second safety parameter is "trip." Assuming the normal state is "0," the TAC 120 outputs a signal indicating the second safety parameter is a "trip," e.g., "0, 1, 0, 0, 0," where "1" is a "trip." Of course this operation is carried out on <u>all</u> four channels.

The VAC 130 receives the trip state of each of the safety parameters determined by the TAC 120 in each of the channels, and determines a final state of each of the safety parameters and then outputs the result. For example, if the trip state of the safety parameter received from the four TACs 120 is "01000", "00100", "00100" and "01000", respectively, the VAC 130 determines that the state of the second safety parameter and third safety parameter are trip states "01100".

The PRC 140 expects a signal pattern to be input from the VAC 130 by using the test signal position bit which is input through the VAC 130 from the TGC 110 and compares the signal pattern on a one to one basis, i.e., bit by bit or signal state by signal state, with the result determined by the VAC 130. If the signal pattern and the result are not consistent, the PRC 140 determines that it should trip the reactor.

Thus, the TGC 110, TAC 120, VAC 130 and PRC 140 are explicitly shown in Fig. 1. Fig. 1 depicts one channel of a plurality or of four channels. Fig. 2 explicitly indicates that there are four channels. New Fig. 3 shows a "prior art" DSS system which is improved by

the present invention. Accordingly, a plurality of measuring channels are shown in the figures. The test input and the test signal position bit are in software, but the test input can be from the field or signal line associated with the TGC 110. The TAC 120 receives safety parameters via a plurality of measuring channels. The TGC 110, TAC 120, VAC 130 and PRC 140 are all also interconnected by communication modules (CM). The VAC 130 receives trip signals from each of the plant operating parameters determined by the TAC over the communication module CM. The PRC 140 compares signals received over the communication module CM with an expected signal pattern in memory. Accordingly, the objection to the drawings under 37 C.F.R. § 1.83(a) with respect to the TGC, TAC, VAC and PRC has been overcome and should be withdrawn.

The Examiner has also objected to the drawings under 37 C.F.R. § 1.83(a) because they fail to show four independent measuring channels (A, B, C, and D), because they fail to show the ENFMS, remote stop panel and CPCS input signals received by the TAC.

As mentioned above, Fig. 1 shows one of the four independent measuring channels and Fig. 2 explicitly indicates that there are four measuring channels. New prior art Figure 3 is a conventional DSS system having the aforementioned four measuring channels. Fig. 1 explicitly shows "field" and "signal" lines coming from the ENFMS, remote stop panel, and/or CPCS providing an input signal therefrom. Accordingly, the objection under 37 C.F.R. § 1.83(a) with respect to the four independent measuring channels and the signals from the ENFMS, remote stop panel and CPCS, has been overcome and should be withdrawn.

The Examiner has also objected to the drawings under 37 C.F.R. § 1.84(p)(5) because they include reference signs not mentioned in the description including "P," "M," "C," "A," "D," "I" and "O."

In the Substitute Specification, the Applicants have included a description of communication modules (CM), processor modules (PM), analog input modules (AI), digital input modules (DI) and digital output modules (DO). Since the elements and labels were shown in the original drawings and are commonly known components of conventional programmable logic controllers (PLCs), no new matter has been added by the description of these elements in

the Specification. Accordingly, the objection to the drawings under 37 C.F.R. § 1.84(p)(5) has been overcome by the amendment to the Specification and should be withdrawn.

Claim Rejections Under 35 U.S.C. § 112

Claims 1, 5 and 7 have been rejected under 35 U.S.C. § 112, first paragraph as containing subject matter which was not described in the Specification in such a way as to enable one skilled in the art to make and/or use the invention. Claims 1, 5 and 7 have been rejected under 35 U.S.C. § 112, second paragraph as being indefinite for failing to particular point out and distinctly claim the subject matter which the Applicant regards as the invention.

In view of the foregoing amendment to the Specification and the claims, the Applicants respectfully submit that the rejections under 35 U.S.C. § 112, first and second paragraphs have been overcome for the reasons that follow.

Claims 1, 5 and 7 in the Specification have been amended to include "a voting algorithm computer (VAC) for receiving <u>a trip state of each of the safety parameters determined by the TAC in each of the channels</u>...." The Specification and the claims have also been amended to include that the voting algorithm computer "(determines) <u>a final state of each of the safety parameters and outputs the result</u>." The PRC computer receives the input from the VAC by using the test signal position bit and "<u>compares the signal pattern on a one to one basis</u> with the result determined by the VAC and if the signal pattern and the result are not consistent <u>the PRC determines to stop or trip the reactor</u>."

Claims 1, 5 and 7 have also been amended to indicate that, *inter alia*, the test input is inserted between actual safety parameters as a test parameter and a test signal position bit indicates position information of the test input.

Claims 1, 5 and 7 have been amended to include, *inter alia*, expecting a signal pattern to be input from the VAC.

Claim 1, 5 and 7 have been amended to include, *inter alia*, the VAC receiving "a trip state of each of the safety parameters determined by the TAC in each of the channels."

Accordingly, it is respectfully submitted that the rejections of claims 1, 5 and 7 under 35 U.S.C. § 112, first and second paragraphs, has been effectively overcome and should be withdrawn.

Claims 2-4 and 6 have been canceled, and therefore, the rejection under 35 U.S.C. § 112 with respect to claims 2-4 and 6 has been effectively rendered moot.

Claim Rejections Under 35 U.S.C. § 102(b)

Claims 1, 5 and 7 have been rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 4,804,515 (Crew *et al.*), hereinafter, "Crew". It is the Examiner's position that Crew discloses a digital online active test-plant protection system in a nuclear power plant including a test generating computer, a trip algorithm computer, and a voting algorithm computer. The Examiner states that Crew also discloses a manual test computer for providing an input/output function by which an operator can monitor and control IS signals from the TGC, the TAC and the VAC, and a remote control module installed in a main control room for displaying the operating state of the system and for performing various functions necessary to monitor, test and maintain the system.

Withdrawal of the rejection of claims 1, 5 and 7 is respectfully requested for at least the following reasons.

<u>Present Invention</u>

The present invention is directed to a digital online active test-plant protection system (DOAT-PPS) in a nuclear power plant. The DOAT-PPS includes a test generating computer (TGC) for generating a test input for self-diagnosis. The test input is inserted between actual safety parameters as a test parameter and a test signal position bit indicates position information of the test input. The DOAT-PPS also includes a trip algorithm computer (TAC) for receiving the safety parameters through the TGC from a plurality of measuring channels which are physically and electrically isolated from each other and then compares the safety parameters and predetermined limit values of the safety parameters to determine a trip state of the safety parameter, if there is a test input by the TGC. The DOAT-PPS also includes a voting algorithm

computer (VAC) for receiving a trip state of each of the safety parameters determined by the TAC in each of the channels, determining a final state of each of the safety parameters and then outputting the result. The DOAT-PPS further includes a pattern recognition computer (PRC) for expecting a signal pattern to be input from the VAC by using the test signal position bit which is input through the VAC from the TGC, comparing the signal pattern on a one to one basis with the result determined by the VAC and then if the signal pattern and the result are not consistent, determining to trip the reactor.

Crew

Crew discloses a distributed microprocessor based sensor signal processing system for a complex process, such as a pressurized water reactor nuclear power plant. Signals from redundant sensors located throughout a pressurized water reactor nuclear power plant are processed in four independent channel sets, each of which includes a plurality of independent microcomputers which calibrate, convert to engineering units and calculate partial trip settings and engineer safeguard actuation signals from the sensor signals for use in the conventional voting logic of a plant protection system. For example, a group of sensors 1, 3, 5 and 7 generate signals which are processed by associated signal processors 9, 11, 13 and 15, respectively. The sensors 1, 3, 5 and 7 and associated signal processors 9, 11, 13 and 15 form channel sets labeled 1-4. Processing of the sensor signals by the associated signal processor 9, 11, 13 and 15 of each channel set 1-4 includes a comparison of the value of the signal with a selected limiting value. If the limiting value is exceeded, a digital partial protection system actuation signal is generated. The partial actuation signal generated by each channel set 1-4 are each applied to identical logic trains 17 and 19 which individually generate protection system actuation signals based upon selected voting logic. If two out of four voting logic has been selected, two out of the corresponding four partial actuation signals must be present in order to generate the actuation signal. The protection system actuation signals include trip signals which open breakers supplying power to under voltage coils on the reactor rod control system to shut down the reactor.

Patentability of Claim 1

Claim 1, as amended, recites, *inter alia*:

> a trip generating computer (TGC) for generating a test input for self-diagnosis, said test input being inserted between actual safety parameters as a test parameter and a test signal position bit indicating position information of the test input...
>
> ...
>
> a pattern recognition computer (PRC) for expecting a signal pattern to be input from the said VAC by using the test signal position bit which is input through the VAC from the TGC, comparing the signal pattern on a one to one basis with the result determined by the VAC, and then if the signal pattern and result are not consistent, determining to trip the reactor.

Crew fails to disclose, teach or suggest a trip generating computer for generating a test input for self-diagnosis where the test input is inserted between actual safety parameters as a test parameter at a test signal position bit indicating position information of the test input. Further, Crew fails to disclose, teach or suggest a pattern recognition computer for expecting a signal pattern to be input from the voting algorithm computer by using the test signal position bit which is input through the voting algorithm computer from the test generating computer, comparing the signal pattern on a one to one basis with the result determined by the voting algorithm computer, and if the signal pattern and the result are not consistent, determining to trip the reactor. Crew discloses a system having independent signal processors which generate a different actuation signal for each channel which are then applied to two identical logic trains which individually generate protection system actuation signals based upon selected voting logic.

A claim is anticipated under 35 U.S.C. § 102 only if each and every element as set forth in the claim is found expressly or inherently described in a single prior art reference. MPEP § 2131. Further, the elements must be arranged as required in the claim. In re Bond, 910 F.2d 831, 15 USPQ2d 1566 (Fed.Cir. 1990). Thus, in order to anticipate a claim, a single reference must teach each and every element of the claim and the elements of the reference must be arranged as required in the claim.

As discussed above, Crew fails to disclose, teach or suggest that the test generating computer generates a test input for self diagnosis and the test input is inserted between actual safety parameters as a test parameter along with the test signal position bit indicating position

information of the test input, as also claimed in independent claim 1, as amended. Further, Crew fails to disclose, teach or suggest a pattern recognition computer which expects a signal pattern to be input from a voting algorithm computer by using the test signal position bit which is input through the voting algorithm computer from a test generating computer, as claimed in independent claim 1, as amended. It is therefore, respectfully submitted that claim 1 is <u>not</u> anticipated by Crew. Accordingly, it is respectfully requested that the rejection under 35 U.S.C. § 102(b) of claim 1, as amended should be withdrawn.

<u>Claims 3-4</u>

Claims 3-4 have been canceled and therefore, the rejections under 35 U.S.C. § 112(b) with respect to claims 3-4 has been effectively rendered moot.

<u>Patentability of Claim 5</u>

Claim 5, as amended recites, *inter alia*:

> a first step of <u>generating</u>, in a test generating computer (TGC), a test input for self diagnosis, said <u>test input being inserted between actual safety parameters</u> as a test parameter and <u>a test signal position bit</u> indicating position information of the test input...
>
> ...
>
> a fourth step of <u>expecting, in a pattern recognition computer (PRC), a signal pattern to be input from the VAC</u> by using the test signal position bit which is input through the VAC from the TGC, comparing the signal pattern on a one to one basis with the result determined by said third step, and then if the signal pattern and the result are not consistent, <u>determining to trip the reactor</u>.

As mentioned above with respect to claim 1, Crew fails to disclose, teach or suggest generating a test input for self diagnosis and that the <u>test input is inserted between actual safety parameters</u> as a test parameter and a test signal position bit indicating position information of the test input. Further, Crew fails to disclose, teach or suggest expecting<u>, in a pattern recognition computer</u> (PRC), a signal pattern to be input from a voting algorithm computer by using the test signal position bit which is input through the voting algorithm computer from the

(test generating computer) TGC, comparing the signal pattern by a one to one basis with the result determined by (a step of receiving a trip state), and then if the trip signal pattern and the result are not consistent, <u>determining to trip the reactor</u>. Instead, Crew discloses partial actuation signals generated by each channel set that are applied at two identical logic trains which <u>individually generate protection system actuation signals</u> based upon selected voting logic. Accordingly, for all the reasons set forth above regarding claim 1, Crew does <u>not</u> disclose each and every element or step of claim 5, as amended. Therefore, claim 5, as amended, is also <u>not</u> anticipated by Crew. Accordingly, it is respectfully requested the rejection under 35 U.S.C. § 102(b) with respect to claim 5 should be withdrawn.

<u>Patentability of Claim 7</u>

Claim 7 is directed to a control program that includes nearly identical steps as set forth above with respect to claim 5. Accordingly, for all the reasons set forth above with respect to claim 5, claim 7 is also <u>not</u> anticipated by Crew. Accordingly, Applicants respectfully request that the rejection with respect to claim 7 under 35 U.S.C. § 102(b) should also be withdrawn.

Claim Rejections Under 35 U.S.C. § 103(a)

Claims 2-6 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Crew and further in view of official notice.

Claims 2 and 6 have been canceled, and therefore, the rejection under 35 U.S.C. § 103(a) with respect to claims 2 and 6 has been effectively rendered moot.

CONCLUSION

In view of the foregoing Amendment and Remarks, it is respectfully submitted that the present application, including claims 1, 5 and 7, is in condition for allowance and such action is respectfully requested.

Respectfully submitted,

POON HYUN SEONG ***et al.***

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(Date)

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Attachments: *New Sheet of Drawing*
Enclosures: *Clean Version of the Specification*
Marked-Up Version of the Specification

MARKED-UP VERSION OF THE SPECIFICATION

DIGITAL ONLINE ACTIVE TEST PLANT PROTECTION SYSTEM IN A NUCLEAR POWER PLANT AND METHOD THEREOF

TECHNICAL FIELD

The invention relates generally to a protection system for nuclear power plant and method thereof. More particularly, the present invention relates to an improved ~~digital software-based~~ digital-based reactor protection system and an ~~engineering~~ engineered safety ~~equipment operating~~ features actuation system.

BACKGROUND OF THE INVENTION

A nuclear power plant is a system to which safety is very important in view of its ~~characteristic~~ characteristics. One of important ~~roles~~ system that must be played for the safety of the nuclear power plant is a reactor protection system. ~~A~~ An Instrument and Control (I&C) system including the reactor protection system is a system that serves as brains of humans in a nuclear power plant, which significantly affects its operation as well as safety of the entire nuclear power plant. Therefore, improvement in the performance of the I&C system such as the nuclear protection system and safety of reliability of a high level will provide significant effects to economic benefits and improved safety in the nuclear power plant.

Most of a reactor protection system in a pressurized light-water nuclear power plant, now widely used in the domestic, is based on an analog circuit, which is composed of a process measuring system ~~consisted~~ consisting of a lot of analog circuit substrates and a solid state protection system (SSPS) made of hardware for performing LCL.

The reactor protection system has several problems, which will be explained as follows.

First, as it is based on an analog circuit, there is a problem in a circuit itself such as drift and worn-out ~~of~~ components.

Second, it requires a periodic check for maintenance. As this check nearly entirely depends on manpower, however, there is a problem that a significant amount of cost and time is wasted.

Third, there is a problem that the reactor is unnecessarily stopped during the check.

Meanwhile, now only the reactor protection system itself is a system consisted of high value-added nuclear power plant safety-class equipments but also most of a rector for receiving signals and other constituent elements are a nuclear power plant safety-class equipments. As most of the nuclear power plant safety-class ~~equipments~~ equipment ~~require~~ requires technology of a high level, a lot of cost for development and purchase are required. In particular, ~~as the~~ an I&C system ~~depending~~ that depends on a foreign technology additionally bears an engineering cost of 3 to 4 times to the cost for manufacturing the equipment, there is a great economic burden. As a concrete example, the plant control system (PCS) included in Gori 2th SSPS costs about 18 millions dollars. If this nuclear power plant I&C system is localized, the engineering cost as well as the manufacturing cost could be significantly reduced. Also, considering that the level of technology in which the nuclear power plant I&C system requires is significantly high, it could be expected that the level of the I&C system related industries could be increased accordingly. In this view, it is very meaningful to localize the reactor protection system that is the core in the nuclear power plant I&C system.

In order to overcome these problems, it is necessary to develop a software based digital nuclear power plant protection system.

Meanwhile, examining a digital plant protection system (DPPS), which has been developed in order to solve the above-mentioned problems, there has been proposed a passive test method in which an alert is issued by an interface & test processor if any problem occurred while continuously monitoring the ~~bi-stable process~~ bistable processor and a LCL processor, and an active test method by which a specific channel is bypassed and a test signal is applied to compare an output signal and a feedback signal.

MARKED-UP VERSION OF THE SPECIFICATION

In the passive test method being an online test, the state of the system is continuously monitored. However, the active test method bypasses and then periodically performs a test, which could not continuously monitor the state of the system.

As a result, as the system test in the conventional digital plant protection system monitors the state of respective channels and components, there is an advantage that relatively detailed information ~~on~~ about the malfunction of specific components may be obtained. However, as it accordingly requires the software of higher complexity and the system test itself is passive, though the system stability could be continuously monitored in a normal state of operation, there is a problem that the stability in the ~~stop~~ trip state of the reactor could not be secured.

SUMMARY OF THE INVENTION

The present invention is contrived to solve the above problems and an object of the present invention is to provide an improved digital software-based reactor protection system and an ~~engineering~~ engineered safety ~~equipment operating~~ features actuation system, which can be applied to present nuclear power plants.

In order to accomplish the above objects, a digital online active test – plant protection system (DOAT-PPS) in a nuclear power plant according to the present invention is characterized in that it comprises a test generating computer (TGC) for generating a test input for self-diagnosis, said test input being ~~a command to initiate a test~~ inserted between actual safety parameters as a test parameter and a test signal position bit indicating ~~that said test input is currently generated at what position of the process parameters~~ a position information of the test input; a trip algorithm computer (TAC) for receiving ~~plant operating~~ the safety parameters through the TGC from ~~via~~ a plurality of measuring channels which are physically and electrically isolated from each other and then comparing the ~~measured operating~~ safety parameters and a predetermined limit values by the safety parameters to determine a trip state of the safety parameters, if there is a test input by said TGC; a voting algorithm computer (VAC) for receiving trip signals from state of each of the ~~plant~~

~~operating~~ safety parameters determined by said TAC in each of the channels, determining ~~whether a reactor has to be stopped or not~~ a final state of each of the safety parameters and then outputting ~~a signal to stop the reactor~~ the result; and a pattern recognition computer (PRC) for expecting a signal pattern ~~from the state of the reactor~~ to be input from the VAC by using the test signal position bit which is inputted through the VAC from the TGC, comparing the signal pattern on a one to one basis with the ~~reactor trip signal generated~~ result determined by said VAC, and then if the signal pattern and the ~~reactor trip signal~~ result are not consistent, determining to ~~stop~~ trip the reactor.

Further, a digital online active test plant protection method in a nuclear power plant comprises a first step of generating, in a test generating computer (TGC), a test input for self-diagnosis, said test input being ~~a command to initiate a test~~ inserted between actual safety parameters as a test parameter and a test signal position bit indicating ~~that said test input is currently generated at what position of the process parameters~~ a position information of the test input; a second step of receiving, in a trip algorithm computer (TAC), ~~plant operating~~ the safety parameters through said TGC from ~~via~~ a plurality of measuring channels which are physically and electrically isolated from each other and then comparing the ~~measured operating~~ safety parameters and a predetermined limit values by the safety parameters to determine a trip state of the safety parameters, if there is a test input in said first step; a third step of receiving, in a voting algorithm computer (VAC), trip ~~signals from~~ state of each of the ~~plant operating~~ safety parameters determined by said second step in each of the channels, determining ~~whether a reactor has to be stopped or not~~ a final state of each of the safety parameters and then outputting ~~a signal to stop the reactor~~ the result; and a fourth step of expecting, in a pattern recognition computer (PRC), a signal pattern ~~from the state of the reactor~~ to be input from said VAC by using the test signal position bit which is input through the VAC from the TGC, comparing the signal pattern by one to one with the ~~reactor trip signal generated~~ result determined by said third step, and then if the signal pattern and the ~~reactor trip signal~~ result are not consistent, determining to ~~stop~~ trip the reactor.

MARKED-UP VERSION OF THE SPECIFICATION

Further, in a recording medium readable by a computer and on which a program is recorded, the program executes a first step of generating, in a test generating computer (TGC), a test input for self-diagnosis, said test input being ~~a command to initiate a test~~ inserted between actual safety parameters as a test parameter and a test signal position bit indicating that said test input is currently generated at what position of the process parameters a position information of the test input; a second step of receiving, in a trip algorithm computer (TAC), plant operating safety parameters through said TGC from ~~via~~ a plurality of measuring channels which are physically and electrically isolated each other and then comparing the ~~measured operating~~ safety parameters and a predetermined ~~limit values~~ setpoints by the safety parameters to determine a trip state of the safety parameters, if there is a test input in said first step; a third step of receiving, in a voting algorithm computer (VAC), the trip ~~signals from~~ state of each of the ~~plant operating~~ safety parameters determined by said second step in each of the channels, determining ~~whether a reactor has to be stopped or not~~ a final state of each of the safety parameters and then outputting ~~a signal to stop the reactor~~ the result; and a fourth step of expecting, in a pattern recognition computer (PRC), a signal pattern ~~from the state of the reactor~~ to be input from said VAC by using the test signal position bit which is input through the VAC from the TGC, comparing the signal pattern by one to one with the ~~reactor trip signal generated~~ result determined by said third step, and then if the signal pattern and the ~~reactor trip signal~~ result are not consistent, determining to ~~stop~~ trip the reactor.

BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned aspects and other features of the present invention will be explained in the following description, taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a schematic view of a digital online active test - plant protection system (DOAT - PPS) at one channel according to one embodiment of the present invention; ~~and~~

MARKED-UP VERSION OF THE SPECIFICATION

Fig. 2 is a diagram illustrating the difference between a conventional digital plant protection system (DPPS), a dynamic safety system ~~(DDS)~~ (DSS) and the DOAT-PPS according to one embodiment of the present invention; and

Fig. 3 is a functional schematic diagram of a prior art dynamic safety system (DSS) as used in comparison in Fig. 2.

DETAILED DESCRIPTION OF THE INVENTION

A digital online active test - plant protection system (hereinafter called "DOAT-PPS") according to one embodiment of the present invention will be described in detail with reference to accompanying drawings.

Fig. 1 is a schematic view of the DOAT-PPS according to one embodiment of the present invention. First, the major components of the DOAT-PPS includes a test generating computer (TGC) 110 for generating ~~test~~ a test input, a trip algorithm computer (TAC) 120 for receiving a ~~safety~~ safety parameter ~~signal to compare~~ and for comparing it with a trip ~~set value~~ setpoint, and to generate a trip ~~signal~~ state, a voting algorithm computer (VAC) 130 for receiving trip ~~signals from other channels~~ state determined by TAC in each of the channels to perform a logic, a pattern recognition computer (PRC) 140 for generating a rector trip signal, a manual test computer (MTC) 150 for providing an input and output function by which an operator can monitor and control input/output signals from the TGC 110, the TAC 120, the VAC 130 and the PRC 140, and a remote control module (RCM) 160 installed at a main control panel, for displaying the operating state of the system and for performing various functions necessary to monitor the test and maintain the system. Each of the TGC 110, the TAC 120, the VAC 130, and the PRC 140 includes a processor module PM, a communications module CM, a digital input module DI and a digital output module DO. At least the TGC 110 also includes an analog input module AI.

The DOAT-PPS according to one embodiment of the present invention is composed of four independent ~~four~~ measuring channels ~~(A, B, C and D)~~ like a conventional DSS (see e.g., Prior Art Fig. 3).

The reactor trip signal is generated when more than two measuring channels among the four measuring channels, that are physically and electrically isolated, surpass a predetermined trip set value. At this time, the trip set value is a value predetermined for the ~~reactor operating~~ safety parameters. If the trip set value is surpassed, it means the state of the reactor is unstable, which will be explained in detail hereinafter ~~explained later~~.

In other words, the function of the reactor protection system is to minimize the possibility that radioactivity can be leaked ~~from~~ to surrounding environments by ~~stopping~~ tripping the reactor, when the nuclear power plant is entered into an abnormal state out of a normal operating state. The reactor protection system receives signals from the reactor and other components to generate a trip signal using trip logic when they get out of normal operation conditions.

The signals inputted into the four independent channels are inputted to the TAC 120 via the TGC 110. Here, the TGC 110 is an integral portion of a digital online active test according to the present invention, which generates a test input and a test signal position bit.

At this time, the test input is a command to start the test. Also, the test signal position bit assists the function of the test input generated at the TGC 110 and also functions to inform that the test input is generated at what position of the ~~process~~ safety parameters. In other words, the DOAT-PPS automatically continuously performs an active test and generates a test input to determine whether respective components are stable or not by replacing an actual input. Therefore, knowing where the test input is located is a very important factor and the test signal position bit functions to inform this position to entire components. Also, a diagnosis for each of the TAC 120, the VAC 130 and the PRC 140 can be made in real time using the test signal position bit.

MARKED-UP VERSION OF THE SPECIFICATION

The TAC 120 ~~generates a self diagnosis test signal~~ determines the trip state of each of the safety parameters and ~~uses the test signal to transmit~~ forwards the trip ~~signal~~ state to the VAC 130. That is, the ~~reactor~~ trip ~~signal~~ state determined by the TAC 120 in ~~one~~ each channel enters the VACs 130 in the four channels as an input signal, and the VAC 130 determines whether ~~the reactor has stopped or not~~ a final state of each of the safety parameters by means of an adequate ~~select~~ voting logic (generally 2/4 logic). The voting logic is a desired or specified item that is selected at the time of constructing a nuclear power plant.

Meanwhile, the PRC 140 expects a signal pattern ~~from a current state of the reactor~~ to be inputted from the VAC and then compares it on a one to one basis with the ~~reactor~~ final trip ~~signal~~ state ~~generated~~ determined by the VAC 130. As a result of the comparison, if they do not match, the PRC 140 determines that the reactor ~~stop~~ should be ~~stopped~~ tripped and transmits it to respective initiation logics.

Also, the MTC 150 provides an input and output function by which an operator can monitor and control input/output signals from the TGC 110, the TAC 120, the VAC 130 and the PRC 140.

In addition, the RCM 160, which is installed at a main control panel, displays the operating system of the system and performs various functions necessary for monitoring and maintenance of the system.

Each of the components of will be below explained in more detail.

First, the TGC 110 is a core portion of a digital online active test according to the present invention and generates a test input and a test signal position bit, which initiates a test automatically.

If the test is automatically initiated, the ~~TAC 120~~ TGC 110 receives ~~plant operation~~ safety parameters as an input signal from an environment neutron flux monitoring system (ENFMS), a remote ~~stop~~ shutdown panel and a core protection ~~calculation~~ calculator system (CPCS) via an analog input module AI or a digital input module DI.

MARKED-UP VERSION OF THE SPECIFICATION

~~Also, the~~ The TAC 120 contains a ~~stop~~ trip algorithm and performs the two following functions.

First, it determines whether the reactor has to be ~~stopped~~ tripped or not using the ~~stop~~ trip algorithm.

Second, it controls the TGC 110. The TGC 110 generates a test input making respective ~~operating~~ safety parameters into reactor ~~stop~~ trip states depending on the ~~stop~~ trip algorithm. The test input is ~~actually~~ inserted between actual ~~plant signals~~ safety parameters as a test parameter for testing. The initiation software of the TAC 120 compares the ~~measured operating~~ safety parameters ~~values~~ and the predetermined ~~limit value~~ setpoint by the safety parameters to determine a trip state using the trip algorithm. The trip ~~signal~~ state is transmitted to the VAC 130 via a programmable logic ~~control~~ controller (PLC) digital output module. That is, the TAC 120 ~~generates a test signal for self-diagnosis~~ determines a trip state of all of the safety parameters by means of the trip logic and transmits the trip ~~signal~~ state to the VAC 130 ~~using the test signal~~.

In the embodiment of the present invention, if the TAC 120 is implemented using PLC, it includes ~~is consisted of~~ a central process module, a power supply module, an analog input module, a digital input module and a digital output module.

Meanwhile, the ~~plant stop operating~~ safety parameters, which are applied to the input terminal of the TAC 120, are as follows.

First, it is a variable over power trip. The change ratio of the neutron flux level is increased over a program ~~set value~~ setpoint or the neutron flux reaches a predetermined maximum value, the reactor is ~~stopped~~ tripped. There is a difference of about 15% between the output and the trip ~~set value~~ setpoint. If the output of the reactor is increased, the trip ~~set value~~ setpoint is also decreased to maintain the range of 13.6%. If the output of the reactor is reduced, the trip ~~set value~~ setpoint is maintained at 13.6%. As the maximum increased ratio of the trip ~~set value~~ setpoint is 14.6%/min, however, if the output of the reactor is increased over the maximum, a trip of the reactor is occurred. The purpose of this trip function is to assist the ~~engineering~~ engineered safety ~~equipment~~

~~operating~~ features actuation system ~~for~~ in mitigating the result of an accident when a control rod is extracted.

Second, it is a high logarithmic power level trip. The high logarithmic power level trip is initiated in order to ~~stop~~ trip the reactor when a predetermined neutron flux output reaches a predetermined maximum value. The purpose of this trip is to secure safety of a cloth and a reactor coolant pressure boundary when accidents such as dilution of boric acid or extraction of an uncontrollable control rod are occurred.

Third, it is a high local power density trip. When a core maximum output density is locally over a specific value, the reactor is ~~stopped~~ tripped. This is caused by generation of a trip signal in the core protection calculator. The input signal used in the trip signal is an output, the location of the control rod, the temperature, pressure and flow rate of the reactor coolant, etc. The purpose of this trip function is so that the local ~~output~~ power density does not surpass the design limit value upon medium frequency and rare frequency accidents. The local output density is calculated in the core protection calculator using the output of a neutron flux and the distribution of a radial-directional output, the output of a radial-direction tip by the measurement of the location of respective rods, and the temperature of the reactor coolant and the output between the temperatures by measurement of the flow rate. The local power density ~~reactor stop~~ trip parameters calculated by the core protection calculator (CPC) are ones that considered an error and a dynamic compensation. This ensures that the tip value of the core local ~~output~~ power density does not surpass the limit value of the local ~~output~~ power density safety limit value after the reactor is ~~stopped~~ tripped when the core local ~~output~~ power trip ~~tip~~ value is actually sufficiently lower than the nuclear fuel design limit value. The dynamic compensation considers the transfer delay of the core fuel center temperature (related to variations of the ~~output~~ power density), delay time of the detector and time delay effect of the protection system. A method of calculating an error of the core protection calculator related to the tip local power density is same to the method used in Departure From Nucleate Boiling Ratio (DNBR) calculation, wherein the DNBR is a physical amount

indicating that ~~a cooling water for cooling a nuclear fuel rod~~ coolant within the reactor is boiled to generate bubbles.

Fourth, it is a low Departure From Nucleate Boiling Ratio trip. If the NBR reaches a predetermined minimum value, the reactor will be ~~stopped~~ tripped. That is, it assists the ~~engineering~~ engineered safety ~~equipment operating~~ features actuation system for mitigating the result when the reactor coolant pump is out of order or the ~~vapor~~ steam generator is leaked. The NBR may be calculated in the core protection calculator using the neutron flux output and the axial-directional ~~output~~ power distribution by the neutron detector in the reactor, the radial-direction tip output by ~~measurement~~ measuring ~~of~~ the locations of each of the control rods, the output between the temperatures by ~~measurement~~ measuring ~~of~~ the temperature and the flow rate of the reactor coolant, the pressure of the coolant system by ~~measurement~~ measuring ~~of~~ the pressure of the pressurizer, the flow rate of the coolant by the speed of the reactor coolant pump and the core inlet temperature by ~~measurement~~ measuring ~~of~~ the ~~reactor coolant low temperature tube~~ cold leg temperature. In this case, considering the delay of the detector and the processing time and inaccuracy, a trip is generated before the NBR surpasses the ~~safety limit value~~ setpoint. Also, the calculation method uses a DNBR calculation method, which ensures that the reactor can be ~~stopped~~ tripped in a state that the calculated DNBR is sufficiently higher than 1.30 so that it does not override the DNBR safety limit value even though the core DNBR value is reduced. The dynamic compensation indicates the transfer delay of the coolant, the thermal delay of the core (related to the core output variations), the time delay of the detector, the time delay of the protection system, etc. The error of the core protection calculator related to the DNBR calculation includes an input measurement error of the core protection calculator, a calculation equation modeling error and a computer process error. The DNBR calculation equation used in the core protection calculator is effective within the predetermined limit value. Therefore, if the core protection calculator is operated out of the limit value, it generates a DNBR/LPD trip signal.

MARKED-UP VERSION OF THE SPECIFICATION

Fifth, it is a high pressurizer pressure trip. This trip is to secure a safety of the reactor coolant pressure boundary when the medium frequency and the rare frequency, which could be over-~~pressured~~ pressurized, ~~are~~ have occurred. If the pressure of the pressurizer is over the set value, the reactor trip ~~is occurred~~ occurs and extraction of the control rod is prohibited.

Sixth, it is a low pressurizer pressure trip. This trip assists the NBR trip, prevents accessing the ~~safety limit value~~ setpoint ands assists the ~~engineering~~ engineered safety ~~equipment~~ features actuation system when an accident such as loss of ~~the~~ coolant accident (LOCA) ~~is occurred~~ occurs. When the plant is stopped or cooled, it allows the operator to manually decrease the ~~set value~~ setpoint. If the pressure is increased, the ~~set value~~ setpoint is increased with a given difference.

Seventh, it is a low steam generator level trip. This trip prevents ~~that~~ the reactor from becoming is pressurized due to the absence of a thermal removal source such as loss of a water supply. That is, when the water level of the steam generator is reduced, a protection action is taken to ensure a time sufficient to operate the assistant water supply pump for removing remaining heat.

Eighth, it is a high steam generator level trip. This trip prevents moisture from a steam generator from entering the turbine, thus preventing damage ~~of~~ to the equipment. That is, if the level of each of the steam generators surpasses the set value, a trip of the reactor occurs ~~is occurred~~.

Ninth, it is a low steam generator pressure trip. This trip assists the ~~engineering~~ engineered safety ~~equipment~~ features actuation system in order to prevent the reactor coolant from cooling when a steam tube is disrupted.

Tenth, it is a low reactor coolant flow rate trip. This trip senses the pressure difference between the front and the rear stairs in the first side of the steam generator. Thus, if this pressure difference falls by a significant ratio or under a predetermined minimum value, a trip of the reactor occurs ~~is occurred~~.

Eleventh, it is a high containment pressure trip. This trip sets the pressure of the container not [[t]] to surpass the design pressure when accidents such as loss of a design standard coolant or damage of a main steam tube within the containment occur ~~are occurred~~. That is, if the pressure within the containment reaches the ~~set value~~ setpoint, a trip signal of the reactor occurs ~~is occurred~~.

Twelfth, it is a manual reactor trip. This trip provides a means for tripping the reactor in the main control room. Also, it is made possible in the reactor trip switching gear.

The VAC 130 receives the trip ~~signals~~ state of respective safety parameters determined by the TAC 120 and a trip channel bypass signal related to it. At this time, it is operated depending on a confirm algorithm by which only one channel can be bypassed at a time. Here, the trip channel bypass means that when one of the four channels could not be operated by an accident, it functions to remove that channel.

In the present embodiment, if signals from more than two channels of the four measuring channels indicate trip states, trip signals are outputted to corresponding safety parameters. If the trip channel bypass exists, more than two of the three trip signals that are not bypassed indicate trip states ~~, a trip signal is outputted~~ to make a trip signal. Also, it receives position information of the test ~~trip~~ input ~~signal~~ for self-diagnosis generated by the ~~TAC 120~~ TGC 110 and then ~~outputs~~ forwards it to the PRC 140.

The RPC 140 receives the trip ~~signal~~ state of each of the safety parameters determined by the VAC 130 and the position information of the test trip signal input for self-diagnosis through the VAC from the TGC. ~~As the~~ The trip state generated in the safety parameters corresponding to the test trip position input means that the system is normal, ~~it does not generate~~ and thus a reactor trip signal is not generated. When the-trip state of the safety parameters not corresponding to the test ~~trip position~~ input ~~and the safety parameters of the test trip location are~~ is normally received, however, a reactor trip signal is generated.

MARKED-UP VERSION OF THE SPECIFICATION

Referring now to Fig. 2, the difference between the conventional digital plant protection system (DPPS), a dynamic safety system (DSS) and the DOAT-PPS according to one embodiment of the present invention will be ~~in detail~~ explained in detail below.

Though all of the three systems are similar since they are based on a software-based digital system, the two systems are different from the DOAT-PPS in several detailed points.

First, examining a control scheme, all of the systems are a software based digital system. Examining major apparatuses, the DSS adopts a board controller scheme but the DPPS and the DOAT-PPS employ a PLL scheme.

Also, all of the three systems perform functions based on the software and have the number of four measuring channels. In view of a test method, the DPPS must be directly initiated by an operator but the DSS and the DOAT-PPS are automatically initiated.

Further, examining a system interface scheme, the DPPS uses an interface & test processor (ITP) scheme but the DSS does not have a specified scheme and the DOAT-PPS is performed in the MTC.

Also, in the test input generation algorithm, the DPPS adopts a predefined scenario algorithm, the DSS adopts a fixed test input algorithm and the DOAT-PPS adopts an intelligent test input generating algorithm and an input signal position bit algorithm.

Also, examining the online diagnostic monitoring section, the DPPS and the DSS adopt a partial diagnostic monitoring scheme but the DOAT-PPS adopts a diagnosis monitor scheme for all the components.

The present invention has been described with reference to a particular embodiment in connection with a particular application. Those having ordinary skill in the art and access to the teachings of the present invention will recognize additional modifications and applications within the scope thereof.

It is therefore intended by the appended claims to cover any and all such applications, modifications, and embodiments within the scope of the present invention.

MARKED-UP VERSION OF THE SPECIFICATION

As mentioned above, the present invention has outstanding advantages that it can design an intelligent test system capable of monitoring the state of all the components as well as all types of errors and it can improve the use and the maintenance.

MARKED-UP VERSION OF THE SPECIFICATION

ABSTRACT OF THE DISCLOSURE

~~There is disclosed an improved digital software based reactor protection system and an engineered safety feature actuation system.~~ A digital online active test - plant protection system in a nuclear power plant ~~according to the present invention~~ comprises a test generating computer ~~(TGC)~~ for generating a test input being ~~a command to initiate a test~~ inserted between actual safety parameters as a test parameter and a test signal position bit indicating ~~that the test input is currently generated at what position of the process parameters~~ position information of the test input; a trip algorithm computer ~~(TAC)~~ for receiving ~~plant operating~~ safety parameters from ~~via~~ a plurality of measuring channels ~~physically and electrically isolated~~ and then comparing the ~~measured operating~~ safety parameters and a predetermined limit values by the safety parameters to determine a trip state, if there is a test input ~~by the TGC~~; a voting algorithm computer ~~(VAC)~~ for receiving a trip ~~signals from~~ state of each of the ~~plant operating~~ safety parameters ~~determined by the TAC~~, determining ~~whether a reactor has to be stopped or not~~ a final state of the safety parameters and then outputting ~~a signal to stop the reactor~~ the result; and a pattern recognition computer ~~(PRC)~~ for expecting a signal pattern ~~from the state of the reactor~~, comparing the signal pattern with the ~~reactor trip signal generated~~ result determined ~~by the VAC~~, and then if the signal pattern and the ~~reactor trip signal~~ result are not consistent, determining to ~~stop~~ trip the reactor.